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WAR INJURIES OF THE EYE.

ALTHOUGH the exposed surface of the eye comprises only about one four-hundredth of the total body surface, it is so vulnerable that injuries to the eye are rather common in warfare. In the 1914-1918 war, eye wounds numbered 8% of all injuries,⁽¹⁾ but in considering this figure it must be remembered that the eyes run an especially grave risk in trench fighting. Many people consider that in the present war much unnecessary damage is being done to eyes by missiles which could be readily stopped by means of a visor. Such protection has been advocated by Cruise, who suggested the use of a visor that weighs less than half a pound and can be attached to a steel helmet,⁽²⁾ but so far the idea has not proved acceptable.

War injuries of the eye can be studied as an isolated subject, but it must be remembered that, in practice, they are usually associated with other injuries, and may often be overlooked, or regarded as unimportant, during the first few days after the wounding. This raises an important point in connexion with the organization of treatment for air-raid casualties: there must be an ophthalmic surgeon working in conjunction with the general surgeons. It is useless to establish an ophthalmic hospital except for patients needing protracted treatment; the eye surgeon must be prepared to go wherever the patients may be found; in return he is entitled to at least a skeleton set of instruments, appropriate drugs, space for an operating site, assistance from nurses trained in ophthalmology, and a recognition of the importance of vision even in a patient who has multiple body injuries.⁽³⁾

CLASSIFICATION OF EYE INJURIES.

War injuries of the eye may be classified as follows:⁽⁴⁾

I. Non-penetrating.

- (a) Foreign bodies in conjunctival sac.
- (b) Concussion injuries of the eye.
 - (i) Hyphæma.
 - (ii) Torn iris.
 - (iii) Torn lens capsule.
 - (iv) Dislocated lens.
 - (v) Vitreous hæmorrhage.
 - (vi) Detached retina.

II. Penetrating but not perforating.

- (a) Wounds of the lids.
- (b) Foreign bodies in cornea or sclera.
- (c) Burns of cornea, lids and conjunctiva.
- (d) Injury from vesicant war gas.

III. Perforating.

Foreign Bodies in Conjunctival Sac.

The presence of a foreign body in the conjunctival sac is a simple and familiar injury, but during air raids there may occur two exaggerated forms: first, the foreign body may be glass or, secondly, the whole of the patient, including the conjunctivæ, may be smothered in fine dust. Glass has to be picked out of the conjunctival sac, but the dust may be removed by irrigation; in both cases the work may be tedious.

Concussion Injuries of the Eye.

Concussion injuries of the eye may occur in wartime as a result of blast injuries as well as from blows with blunt objects. The mechanism of the injury is that the eye is driven against the orbital fat and therefore flattened from

before backwards. At the same time the fluid of the anterior chamber is forced backwards and also laterally so that the iris and lens are exposed to damage.

Hyphæma.—Hæmorrhage into the anterior chamber usually absorbs without incident, but on the second to the fifth day there is a danger of recurrent hæmorrhage. This second hæmorrhage is the more dangerous, for it is liable to lead to secondary glaucoma or vitreous hæmorrhage, each of which takes months to clear. It is therefore wise to keep a patient with hyphæma in bed for more than five days.

Torn Iris.—A radial tear in the sphincter muscle of the iris may follow a blow with a blunt object. It is important not to use a mydriatic in treating these patients. Other forms of injury to the iris are detachment and retroflexion. It is characteristic of the iris, as of other specialized tissue, that losses of substance are never repaired with the original type of tissue. Retroflexion can, of course, be remedied surgically and an attempt may also be made to stitch a detached iris into the filtration angle.

Torn Lens Capsule.—Rupture of the lens capsule usually occurs near the equator. A traumatic cataract results from the action of the aqueous or, more slowly, from the action of the vitreous, on the lens fibres. If the tear in the capsule is large the continued exposure to the aqueous may cause the opaque lens substance to be dissolved. Traumatic cataract can be treated satisfactorily; it is not an urgent condition.

Dislocated Lens.—Rupture of the suspensory ligament may lead to partial or complete dislocation of the lens. Tremulousness of the iris occurs with most complete dislocations, as the iris is no longer supported by the lens. In subluxations the edge of the lens may appear, on ophthalmoscopic examination, as a crescentic black line crossing the pupil. Complete forward dislocation is highly dangerous, for the lens causes severe irritation, and blocks the filtration of aqueous, so that a secondary glaucoma is likely; an immediate attempt should be made to remove the lens. Backward dislocation may also eventually give rise to glaucoma, or may cause irido-cyclitis by pressure on the ciliary body.

Vitreous Hæmorrhage.—Small quantities of blood produce only a cloudiness of the vitreous, but large effusions may obscure the red reflex completely. Vitreous hæmorrhages may take many weeks to absorb.

Detached Retina.—In recent cases where the vitreous and intraocular structures are not grossly diseased, and where the detachment can be localized, there is a reasonable chance of replacing the retina by operation.

Foreign Bodies in Cornea and Sclera.

The proper removal of foreign bodies from the cornea and sclera requires and repays more care than is usually given to it. The eye should be anesthetized by the instillation of two drops of 3% cocaine solution or other local anæsthetic. It is essential to have a good light, and this should be focused on the eye with a condensing lens. The foreign body is removed with a spud or needle. Sometimes when the foreign body is lodged in the conjunctiva it can be best removed by gripping the conjunctiva with fine forceps and snipping off the appropriate piece with scissors.

Healing usually takes place within twenty-four hours, but should be assisted by the use of silver proteinate or other antiseptic, and by the application of a pad and

bandage for twenty-four hours. If there is more than a slight degree of ciliary injection it is wise to use atropine or one of its substitutes.

If the fragments are embedded deeply in the cornea, care must be taken in their removal lest they be pushed inward and open up the anterior chamber. A broad needle is passed into the anterior chamber to support the posterior wall of the cornea and to press the foreign body forward during removal. This should be attempted only by those with special training in ophthalmology.

If the particle is embedded in the sclera, a conjunctival flap has to be turned back. When the fragment is so deeply placed that perforation is feared, scleral sutures should be applied before removing it and instruments should be ready to deal with prolapsed uveal tissue.

Some people are likely to have multiple particles embedded in the cornea as a result of air raids. These foreign bodies cause intense lachrymation and photophobia. It is impossible to remove them all at one sitting; perhaps it is best in the first instance merely to apply 0.5% atropine in oil and to wait for a day or two so that the more superficial particles fall out of their own accord. Those that are left can then be removed, but deeply embedded glass fragments cause little or no reaction and are best left alone if the track epithelializes.

Wounds of the Lids.

When the lids are wounded the skin is cleaned thoroughly with soap and water, the lashes are clipped and the eyebrows shaved. Since the blood supply of the lids is very rich, excision of lid lacerations need not be extensive; if the wound is sutured without much sacrifice of tissue, rapid healing will usually follow. Every care should be taken to see that the edges of the wound are brought into accurate alignment; otherwise ectropion or entropion is likely to result, and in the latter case, corneal ulceration may be caused by the intumed lashes. The wound should be closed in three layers—the conjunctiva and the muscle layer with "0000000" catgut, and the skin with interrupted black silk sutures. Notching at the lid margin is to be avoided in the case of wounds that have split the free border of the lid. It will help towards this end if vertical cuts are sutured so that the layers of stitches do not lie on top of one another, but are terraced, and a stitch is put in the upper free margin of the lid.

Special care must be taken if the wound involves the inner end of the lower lid where it may cut the lower canaliculus; faulty suturing will leave a permanent epiphora. If treated early the wound may easily be closed satisfactorily: a number one probe is threaded through the lower punctum to emerge at the upper part of the wound. The probe is then used as a lever to pull the torn lid into alignment and is passed on into the lachrymal sac. The wound is then sutured accurately, the sutures including the cut lid margin. The projecting portion of the probe is cut off and the end bent away from the eye. The probe is left in position for about six days; subsequently further probing is necessary to prevent the formation of a stricture. Binocular dressings are essential for all wounds of the lids.

Burns of the Cornea, Lids and Conjunctiva.

In burns of the face the cornea frequently escapes injury because of the protection of the eyelids. There have even been some instances in which hot metal entered the conjunctival sac without burning the cornea, and the explanation advanced is that the latent heat of evaporation of the tears is supplied by the metal, which therefore quickly cools to a harmless temperature.

It is generally agreed that coagulation methods of treatment are not suitable for burns of the eyelids or surrounding skin: contraction of the coagulum draws the lids away from the eyeball and causes an "exposure keratitis" which may progress to a stage where removal of the eye is necessary. If the lids have only superficial burns sterile "Vaseline" or *tulle gras* is a very good dressing. By this means the mobility of the lids is maintained. If the burn is of third degree skin grafting may be required, and the best preparation for this is the use of saline compresses together with sulphonamide and *tulle gras* dressings.

The cornea is involved severely in many cases of incendiary bomb injury. Frequently both eyes are affected and numerous foreign bodies are embedded in the cornea. The lids and conjunctivae swell and the corneal epithelium is so oedematous that removal of the foreign bodies is impossible for about a week. Pain is excessive, but it has been found that "Metycaine" and "Merthiolate" ointment used in the early stages, produces great relief without harming the cornea.⁽¹⁾ Atropine is also applied, and, when the pain subsides, the eye is irrigated with an antiseptic lotion. One important function of the irrigation is to prevent the formation of adhesions between the cornea and lid. Recovery is slow even when infection does not complicate the course.

Injury from Vesicant War Gas.

Mustard gas and lewisite are powerful vesicant liquids which may enter the eye either as splashes of liquid or as vapour. Their effects on the eye are similar and the treatment is the same.

The destructive action on the eye is apparently very rapid, but the effects are not obvious for two to forty-eight hours after the injury. Lachrymation, extreme photophobia and moderate pain occur, the conjunctivae become congested, and the eyelids swell rapidly. The most severe lesion occurs, of course, in that part of the eye exposed through the palpebral fissure. About twenty-four hours after the lesion first appears a white band may be seen in some cases stretching across this region and contrasting with injected areas above and below. The white band indicates a severe type of injury in which oedema has compressed the vessels and made the area relatively bloodless. Ulceration of the cornea may occur and some of the severe ulcers may cause permanent opacities.

Irrigation should be used only if there is liquid vesicant in the conjunctival sac and only if the patient is seen within five minutes of the injury. Water or normal saline solution is a suitable irrigating fluid. Atropine should be used to secure and maintain dilatation of the pupil, and pain, if present, may be relieved by 0.5% solution of dionine. Albuclid in the form of a 2.5% solution should be instilled into the conjunctivae three or four times a day. The eyes should not be bandaged.

About 75% of the patients, as judged from the experience in the Great War, are only mildly affected, and recover in two weeks. The very severe injuries make up about 10% of the total. The development of an intractable corneal ulcer many years after the original injury is a proven but rare event.

Perforating Injuries.

Diagnosis.

The diagnosis of perforation may sometimes be difficult, especially when the missile has entered through the sclera and nothing abnormal can be seen on inspecting the exposed surface of the eye. The history may be helpful and may give information about the type of missile concerned. A thorough examination should be made for the presence of a wound in the eye or eyelids. Prolapse of uveal tissue or of vitreous may be seen, or the loss of intraocular contents may be surmised from a fall in intraocular pressure or a change in the depth of the anterior chamber. Visual acuity is diminished on the injured side. The pupil should be dilated and the eye examined by means of an ophthalmoscope and a slit lamp.

In any case of doubt skiagrams should be taken to detect and localize foreign bodies. The anterior segment of the eyeball can be explored by means of a bone-free film taken after a contact lens with four radio-opaque markers has been slipped over the cornea as a guide to the position of the foreign body.⁽²⁾ These films are very sensitive and will reveal small fragments of glass or metallic bodies so minute as to be invisible on ordinary films. The retrobulbar injection of three cubic centimetres of "Novocain" increases the size of the segment that can be explored in this way.

One must use, in addition, a method of localization which can be applied whatever the position of the foreign body in the globe. There are many methods available; one recently described is simple and has worked satisfactorily under war conditions in Libya.⁽³⁾

As a result of the complete investigation of the eye one decides whether a foreign body is present, and whether the eye has become so disorganized that it has to be removed. The treatment can therefore be considered under three headings: (a) removal of an eye; (b) removal of intraocular foreign bodies; and (c) repair of perforating wounds of the globe.

Removal of an Eye.

General anaesthesia may sometimes be desirable, in which case the intravenous use of "Pentothal" is suitable. It is possible, however, to produce adequate anaesthesia by means of a retrobulbar injection of "Novocain"; this is usually combined with a facial nerve block, and premedication by means of either "Luminal" or morphine and atropine.

If the eye is not infected it can be removed by excision; perforations of the globe should be sewn up before the excision is attempted. The operation of excision is simple, but in view of an error sometimes made in the present war it should be emphasized that the maximum amount of conjunctiva should be retained in order to provide a roomy socket. War injuries often involve both eyes, and in such cases one should hesitate to remove either eye until it is clear which has the better sight.

If there is gross soiling of orbital tissues it is better to perform an evisceration rather than excision of the globe. The cornea is removed by cutting around the corneoscleral margin with scissors. This then provides an opening into the globe and the contents can be scooped out; the cavity is wiped carefully with gauze so that all uveal tissue is removed. Next, the sclera is packed with gauze and the conjunctiva and muscles are stripped from it. The sclera is cut across just in front of the insertion of the optic nerve into the globe. The operation is concluded by stitching the conjunctiva together; the orbit must never be packed. If excess sclera is left it sloughs out over a period of several weeks because it has inadequate blood supply. Unless the frill is left, however, the sheath of the optic nerve is opened up and a pathway provided for spread of infection to the meninges.

Attention has recently been drawn to the importance of after-care of the socket in giving a good cosmetic result under war conditions. There are two factors tending to produce an unsatisfactory socket: formation of scar tissue with partial obliteration of the cavity; and contraction deformity of the eyelids. The former is inevitable to some extent when the damage is widespread, but is made worse by the presence of infection; the wasting and contraction of the lids need not occur. A temporary prosthesis made of gutta percha or acrylic has a favourable influence on both of these complications. By exerting a pressure on the granulating tissue, it promotes healing, and, by maintaining the lids in their normal position, it prevents contraction and encourages lid movement. The prosthesis should be removed and cleaned at least twice a day, and mild antiseptic drops instilled into the socket at the same time. The artificial eye may be fitted within six weeks in uncomplicated cases; if sepsis is present the causative organism should be identified and treated, and a prosthesis fitted as soon as the infection has been controlled. The danger in wartime is that the patient may be left so long without a prosthesis that the upper fornix will acquire permanently that sunken appearance which directs attention to the artificial eye.⁽⁶⁾

Intraocular Foreign Bodies.

The modern technique for the removal of intraocular foreign bodies has recently been described⁽⁷⁾ and the detail will not be repeated here. An essential preliminary is the accurate localization of the foreign body. Surface and retrobulbar anaesthesia are used in combination for the operation.

Foreign bodies fall into two main classes, depending on whether they are magnetic or not. In civil practice the majority of intraocular foreign bodies are magnetic, but, on the whole, this is not true in wartime. For example, glass has proved to be one of the commonest causes of eye injury in air raids on towns; again, fragments of the hand grenades, booby traps and land mines used by

the Italians in Libya were non-magnetic, and pieces of shells and bombs often only weakly magnetic. In cases in which the body has been peppered with missiles, a preliminary test for magnetic properties and opacity to X rays may be made on pieces extracted from the skin.

Magnetic Foreign Bodies.—Magnetic foreign bodies may be removed by one of two routes: (a) the anterior route and (b) the posterior route. When the anterior route is used the foreign body is attracted forwards by a giant electromagnet through the suspensory ligament of the lens to the posterior aspect of the iris. The dragging of the foreign body against the iris is very painful. When this pain is experienced and the foreign body is seen to be bulging the iris, the direction of the magnetic force is changed so that the foreign body moves along behind the iris towards the pupil. It passes through the pupil into the anterior chamber from which it is extracted by means of a small magnet through an incision made in the cornea with a keratome.

When the posterior route is used the sclera is exposed by turning back a conjunctival flap either at some site of election or else at the site of the wound in the sclera. The opening in the sclera is enlarged to a size which is adequate for the passage of the foreign body and the magnet terminal is placed at the lips of the scleral wound.

The disadvantage of using the posterior route is that if the foreign body is non-magnetic the exposure of the sclera might have been made in vain; but a technique has been developed whereby even a non-magnetic foreign body may sometimes be removed by the posterior route. A thin pair of straight iris forceps is passed into the vitreous under direct vision through an ophthalmoscope, and the foreign body withdrawn through the scleral opening. Some 50% of foreign bodies in the vitreous can be seen by means of the ophthalmoscope.

The posterior route has certain advantages: (1) It is adapted for removal of the large and irregular foreign bodies which are relatively common in warfare and which, if drawn forward, may damage the ciliary body, iris or lens. (2) If the foreign body is only slightly magnetic and is lying towards the posterior pole of the eye, the magnet may have to be brought nearer to it than is possible by the anterior route.

Non-Magnetic Foreign Bodies.—Non-magnetic foreign bodies can sometimes be removed from the vitreous by the technique already described. If they are present in the anterior chamber, they must be removed by forceps or iris hook through an incision in the cornea; there is a risk of injuring the lens during the manipulation. If the foreign body cannot be extracted, the eye usually has to be removed eventually, but there are some cases in which a retained foreign body has remained indefinitely without causing much harm. Glass in the vitreous is often relatively harmless, but when present in the anterior chamber it is likely to irritate the cornea and eventually cause such damage that excision is required. Splinters of wood usually provoke a severe inflammation.

Infection Associated with Foreign Bodies.—Infection is likely to follow a perforating wound which involves either the lens or the vitreous, but is much easier to control if the foreign body is in the anterior chamber. The infection is often pyogenic, but in suitable circumstances either tetanus or gas gangrene may occur. A sign of developing panophthalmitis is a rapid loss of visual acuity and an inability to localize the source of a light shone on the eye. The treatment of panophthalmitis is evisceration of the eye involved.

The general treatment includes the administration of sulphonamide, and protein shock therapy by means of milk injections. The initial dose of sulphapyridine or sulphathiazole by mouth is two grammes, and subsequently one gramme is given every four hours, day and night, until improvement has occurred. The amount given is then successively reduced to zero over a period of about a week.

Pyogenic infection does not cause sympathetic ophthalmia, but this dreaded complication may follow perforating wounds of the eye, especially when the iris or lens prolapses into the wound. It is not known whether the ophthalmia is infective in nature or whether it is in

some sense an allergic manifestation. The condition begins as an irido-cyclitis in the injured eye, followed after an interval by similar changes in the sound eye and often progressing to blindness. The interval is usually from four to eight weeks, but may be as short as ten days. If, therefore, enucleation of a damaged eye is to prevent the development of sympathetic uveitis, it should be carried out within two weeks of the time of injury. Once the condition has fully developed, enucleation of the exciting eye is of no benefit, and the eye should be retained, as it sometimes proves to have the better vision.

The rules for the prevention of sympathetic ophthalmia may be summarized as follows: if the eye is so badly injured that there is little or no chance of recovery of vision, it should be removed; if useful vision is present in the injured eye the decision may be difficult, but factors favouring the development of sympathetic ophthalmia are large wounds, prolapse of uveal tissue and youth of the patient. Prompt enucleation is safest in doubtful cases when the patient is a child or when the conditions of war make it impossible to ensure skilled care and observation. In a well-equipped clinic more conservatism is recommended, for treatment of the injury is more likely to be effective and examination of the uninjured eye with a slit lamp will show the earliest signs of sympathetic inflammation.

Although the occurrence of sympathetic ophthalmia is a major tragedy, one should remember that it was almost non-existent in the 1914-1918 war, and has not so far proved troublesome in this war. One authority, however, states that the condition occurs in 1% of all perforating injuries,⁽¹⁾ so that its scarcity in wartime is probably due to prompt enucleation of damaged eyes or prompt excision of prolapsed uveal tissue.⁽²⁾

Repair of Perforating Wounds of the Globe.—When the wound involves the cornea, or extends from the cornea into the sclera, prolapse of the iris is likely to occur. This is a grave complication and calls for immediate surgical interference. If the iris is allowed to remain prolapsed, any of the following may result:

1. The wound may be very slow in healing and may never consolidate properly.

2. Vision may be interfered with, partly because the corneal scar will distort rays of light entering through it, and partly because the pupil may be dragged in the direction of the corneal wound and so lose its central position.

3. Infection may readily occur.

Because of these complications a prolapsed iris is dangerous. Even if the prolapse can be reduced there is the danger that the iris has been contaminated during exposure, and the better treatment, therefore, is to excise the presenting knuckle of iris. Perforating wounds that are complicated by prolapse of uveal tissue should be treated as soon as possible.

Perforating Wounds of the Cornea with Iris Prolapse.—As for other perforating injuries, surface and retrobulbar anaesthesia is used in the treatment of perforating wounds of the cornea with iris prolapse and the facial nerve is blocked. The wound can be brought accurately into the field of view by means of a stitch placed through the superior rectus. The prolapsed iris is seized with toothed iris forceps and pulled gently so as to free it from adjacent tissue. When this has been accomplished the prolapse is gripped at its base with Couper's capsule forceps. It is then removed with one snip of de Wecker's scissors, which are gently pressed against the surface of the cornea while cutting. A brisk haemorrhage soon fills the anterior chamber and makes impossible any second attempt to deal with the prolapse. If the operation is successful the cut margin of the iris slides back into the eye and leaves a coloboma with the pillars free.

In some cases the wound is irregular or valved and the iris cannot be readily freed. It is then necessary to remove as much iris as can be mobilized and to free the remainder by means of an iris repositor introduced into the anterior chamber through an incision made in the cornea opposite the wound.

Removal of the prolapsed portion of an iris may be carried out up to ten days after the injury.

Perforating Wounds of the Cornea without Iris Prolapse.—Many of those injured by glass in air raids have perforating wounds of the cornea without prolapse of the iris and without retention of a foreign body. If the edges of the corneal wound do not lie in accurate contact, conjunctiva should be used to cover the gap. A flap of conjunctiva is raised with its root as near as possible to the wound and its pedicle formed from the conjunctiva bordering on about half the corneo-scleral margin. This flap is laid across the diameter of the cornea so as to cover the wound, and is held in position at each end by sutures. Soft boric ointment with 1% atropine is placed inside the eyelids and both eyes are bandaged to avoid movement. A little ointment may be slipped into each conjunctival sac daily. In about five days the sutures will cut out and frequently the conjunctiva retracts to show a healed cornea.

In cases in which there is a relatively wide gap between the edges of the corneal wound, it may be necessary to stitch the cornea with very fine silk. The band of conjunctiva is placed over the cornea as usual and the stitches are taken through it.

Perforating Wounds at the Corneo-Scleral Margin.—Perforating wounds at the corneo-scleral margin are likely to be complicated by prolapse of the iris. It is often necessary to make a preliminary incision through the cornea to admit the iris repositor. After the prolapsed iris has been removed, a flap of conjunctiva should be stitched over the wound.

Perforating Wounds Extending from the Cornea to the Sclera.—When wounds extend from the cornea to the sclera the conjunctiva should be cut back so that the full extent of the scleral wound may be seen. The conjunctiva is then retracted and an excellent view of the prolapsed uvea results. The prolapsed tissue is cut away and the conjunctiva stitched together again. It is often dangerous to attempt to stitch the tough sclera, for the pressure necessary may squeeze vitreous from the globe, but some surgeons over-sew clean-edged, linear wounds of the sclera.

Perforating Injury of the Lens.—In any of the preceding conditions the lens may also be injured and a traumatic cataract occur. If the lens is obviously swelling and lens matter coming forward into the anterior chamber, it is usually wise to remove as much of the lens as possible by the gentle use of a curette and anterior chamber irrigator. In mild cases of traumatic cataract atropine is used freely and the lens is left for subsequent treatment. When the lens prolapses through a corneal wound an anterior synechia almost always occurs. It is unwise to operate when the lens capsule has been punctured posteriorly, for vitreous is bound to come forward into the anterior chamber.

Posterior Perforation of the Eyeball.—If splinters penetrate the eyeball from the back or the side, a condition occurs in which there are deepening of the anterior chamber, depression of the iris, softness of the eyeball and haemorrhage into the interior of the eye. It is impossible to save the sight in such an eye and enucleation should be carried out.

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